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MONTANA DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION

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October 10, 1973

Following is the Draft Environmental Impact Statement for a proposed weather modification program in the Hungry Horse area of western Montana. A permit to modify precipitation is required before the program, proposed by the Bonneville Power Administration, may begin. Pursuant to the Montana Weather Modification Act of 1973 (Section 89-318, R.C.M. 1947), the Montana Board of Natural Resources and Conservation will either grant or deny the permit to the organization which will actually conduct the project. In this instance it is North American Weather Consultants, a private contractor.

I encourage you to carefully review this statement and invite your response. Any written comments that you might have should be submitted to me by November 1, 1973. If a final impact statement is prepared, your written comments will be included.

The Department's final action on this permit request will be based on the response to this Draft Environmental Impact Statement and a public hearing. The hearing will be held October 30, 1973, in the Junior High School gymnasium at Kalispell, Montana, and will begin at 8:00 p.m.

Prepared in compliance with the Montana Environmental Policy Act, Section 69-6504(b)(3), this Draft Environmental Impact Statement was submitted to the Environmental Quality Council on October 10, 1973.

Sincerely,

Lawrence M. Jakub

LAWRENCE M. JAKUB
SPECIAL STAFF ASSISTANT

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED

HUNGRY HORSE
WEATHER MODIFICATION
PROJECT

Prepared by

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

Submitted pursuant to:

Montana Environmental Policy Act

Section 69-6504 (b) (3)

October 10, 1973

I. INTRODUCTION

Atmospheric water constitutes a tremendous natural resource upon which all forms of life are dependent. Historically, the availability of this resource has been dependent on the forces of nature, and any intervention by man has been largely ineffective. This situation no longer prevails with the advent of new and effective weather modification techniques and a concomitant greater attention being directed toward precipitation management programs.

Since this water source is such a valuable commodity and weather modification generally has such a broad geographical impact, the 1967 Montana Legislature enacted legislation (Sections 89-310through 89-331, R.C.M. 1947) which provides for the regulation of any development of atmospheric water. As defined by this Act, weather modification and control means:

> changing or controlling, or attempting to change or control by artificial methods, the natural development of any or all atmospheric cloud forms or precipitation forms which occur in the troposphere.

As a means to regulate weather modification efforts within Montana, the law requires potential modifiers to obtain a license and a permit. The license requirement assures that the individual who controls a project has the necessary meteorological competence. The decision on a permit involves public participation as a means for the public to express their opinions on the desirability of a particular project. Prior to issuing a permit, a public hearing may be held as a means to obtain public input. Although the Montana Act is administered by the Department of Natural Resources and Conservation, the ultimate decision on either a license or a permit rests with the Board of Natural Resources and Conservation and a concerned citizenry.

On September 13, 1973, the Department of Natural Resources and Conservation received applications for both a license and permit to conduct weather modification operations in the South Fork of the Flathead River Drainage, above Hungry Horse Dam. The applicant, North American Weather Consultants, is a private firm contracted by the Bonneville Power Administration to conduct the actual operations. The Bonneville Power Administration is a federal agency responsible for marketing the electrical energy produced at twenty-seven hydroelectric projects in the northwest. The electrical energy from these projects comprises about fifty percent of the gross electric reserves in the region.

Below-normal precipitation this past winter has resulted in low stream runoffs and consequently, the major power producing reservoirs administered by Bonneville Power are below their capacity. Generating capacity is such that Bonneville Power is predicting a firm power deficiency of 4.6 billion kilowatt-hours in February, March and April. This deficiency is approximately equal to the yearly electrical requirement of about 290,000 average-size homes (Bonneville Power Administration, 1973 b).

Several Bonneville Power actions have been undertaken to alleviate this potential shortage and include curtailment of interruptible power to industrial customers, a voluntary conservation program and importation of power from outside the region. It is hoped that these actions will alleviate the deficiency. Nevertheless, Bonneville Power is concerned that the coming winter may be sufficiently dry to result in power shortages during the 1974-1975 operating year. As a possible means to reduce the magnitude of this shortage, Bonneville Power is proposing the weather modification program which will be conducted by North American Weather Consultants. The intended one-year cloud seeding program is hopefully expected to increase the snowpack by about ten percent. Assuming median year water conditions, this effort is expected to increase generation capacity within the entire Bonneville system by 220 million kilowatt-hours or sufficient energy to meet the yearly electrical demands of 15,000 average homes.

The Montana Environmental Policy Act (Sections 69-6501 through 69-6517, R.C.M. 1947) and guidelines adopted by the Montana Environmental Quality Council require State agencies to prepare environmental impact statements when acting upon permit requests for operations that may significantly affect the environment. A statement is also required if an action is of a controversial nature. The Department of Natural Resources and Conservation has determined that prior to acting on the permit request by North American Weather Consultants, an environmental impact statement must be prepared, because (1) the proposed operation may create a significant environmental impact, and (2) since a wilderness area is affected, it is certain to be a controversial issue.

This evaluation of environmental impact concerns a specific, operational weather modification proposal which is not designed as a research program. Impacts which could result from the proposed winter seeding program were determined on the basis of the unique set of conditions which prevail within the target area. Conclusions reached are not intended to be broadly extrapolated to other areas and weather modification efforts which involve carefully-planned research, e.g., the High Plains Cooperative Program, a research endeavor endorsed by the Department of Natural Resources and Conservation.

II. DESCRIPTION OF THE PROPOSED ACTION

Background

Weather modification is not a new activity to the South Fork of the Flathead River. During the five-year period, 1966 to 1971, Bonneville Power funded winter cloud seeding operations in the Hungry Horse drainage area. However, technical guidance and contractual administration of the projects were provided by the Bureau of Reclamation, Division of Atmospheric Water Resources Management. North American Weather Consultants, a private contractor, was responsible for the actual cloud seeding operations. The stated purpose for that five-year program was:

> to increase snowpack in order to permit release of additional water from the Hungry Horse Reservoir for power production, and still be reasonably assured the reservoir will refill following the drawdown period (Bonneville Power Administration, 1972).

Although planned for the winter of 1971-72, the weather modification program was discontinued when the Department of Natural Resources and Conservation (then the Montana Water Resources Board) denied the annual weather modification permit. The reasons for denying the permit were:

1. A final environmental impact statement was not submitted by the United States Bureau of Reclamation as required by the National Environmental Policy Act;

2. There was no firm showing that weather modification activities may legally be conducted in a designated wilderness area under the United States Federal Wilderness Act. Conflicting and inconsistent testimony was offered by the United States Department of Interior and the United States Department of Agriculture on this point; and

3. There was insufficient evidence that the weather modification activities did not have an adverse environmental effect on Montana's natural resources including timber and wildlife, and substantial evidence was presented by interested persons to the effect that such activities were in fact detrimental.

In August of 1972, Bonneville Power decided that cloud seeding operations in the Hungry Horse area would be discontinued until at least November, 1975. Reasons cited for this decision included: (1) a need to update and improve the efficiency of the operation, (2) the necessity of preparing an environmental impact statement on the project and (3) a need to analyze results of the Bureau of Reclamation weather modification-ecology project in the San Juan Mountains of Colorado (Bonneville Power Administration, 1972).

Objectives of the Proposed Operation

Although Bonneville Power previously decided that cloud seeding operations would be ceased in the Hungry Horse area, the current power situation in the Northwest has led to a reassessment of that decision. Consequently, Bonneville Power has decided to initiate a one-year, operational, winter cloud seeding program. The purpose of the proposed action is to augment the snowpack within the Hungry Horse target area thereby increasing the possibility of an average snowpack. Bonneville Power feels that a ten percent increase in snowpack is likely, which under median year conditions would increase generation ability by approximately 220 million kilowatt-hours.

Location of the Proposed Operation

The target area for the proposed weather modification effort is the drainage area of the Hungry Horse Reservoir (see figure 1). Specifically, the area is that portion of the South Fork of the Flathead River drainage which is above the Hungry Horse Reservoir. Bounded on the east by the Flathead Mountains and on the west by the Swan Mountains, the 1,034,600-acre target area consists of a large portion of the Bob Marshall Wilderness Area.

The Hungry Horse area is the chosen site since runoff water produced at this Montana location can be used at a larger number of hyroelectric generating facilities. Before water from the area reaches the Pacific Ocean, it passes through twenty hydroelectric dams on the Clark Fork and Columbia Rivers. Another reason for choosing this area centers around the previous cloud seeding experience in the area and the greater chances for a successful program.

Duration of the Proposed Project

The operation is planned to commence by November 15, 1973 and would terminate no later than April 15, 1974. Operations would proceed until the measured snowpack reaches normal water content. Previous operations in the Hungry Horse area were generally terminated before April due to the natural adequacy of the snowpack. Listed below are the dates when seeding was terminated during the previous weather modification effort:

Winter	Seeding Terminated
1966-67	February 28
1967-68	April 30
1968-69	January 15
1969-70	March 31
1970-71	December 31

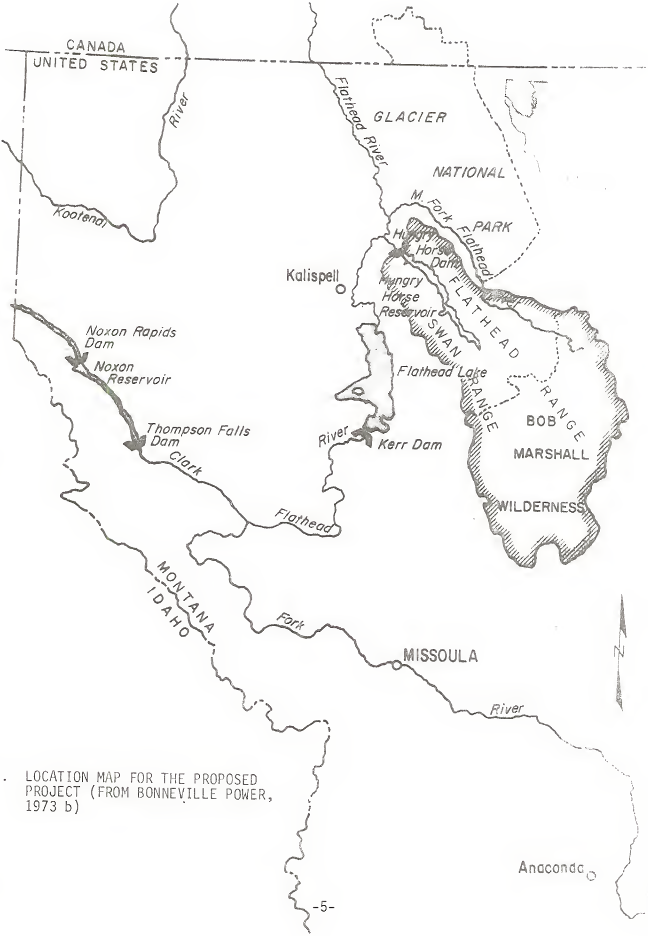

FIGURE 1. LOCATION MAP FOR THE PROPOSED PROJECT (FROM BONNEVILLE POWER, 1973 b)

Seeding System

The primary goal of the proposed operation, similar to all other weather modification operations, is to increase the number of ice-forming nuclei in the cloud systems. These sub-microscopic particles, which are commonly in short supply, are necessary to convert super-cooled cloud droplets to ice crystals. If converted to ice crystals, they are able to become larger at the expense of water vapor and water droplets in the cloud. (A difference in vapor pressures of ice and water accounts for this ability; air which is supersaturated as to ice may not necessarily be saturated as to water). Ice crystals may become sufficiently large that they are able to fall in relation to the surrounding air and, depending upon the temperature below the cloud base and its height, the ice crystal will either reach the ground as snow or rain, or it will evaporate.

The system proposed for the Hungry Horse project will utilize a line of ten, manually-operated generators which produce 10^{14} to 10^{15} artificial ice-forming nuclei per gram of silver iodide. (See figure 2). These ice-nuclei are produced by burning a solution of silver iodide, ammonium iodide and acetone in a propane flame. The resulting sub-microscopic silver iodide crystals which serve as the ice-forming nuclei become effective at temperatures of 5°F (-15°C).

In order for a storm to be seedable it must satisfy three criteria:

1. The average wind must be from the west in order that the seeding effect will take place over the target area;

2. The air must be unstable so that the silver iodide crystals will rise into the storm system; and

3. The temperatures within the storm must be between minus 5°C and minus 25°C.

If any of these criteria are not met the storm is declared unsuitable for seeding. If a storm is seedable, the appropriate generators are turned on, although all generators are never used simultaneously. Pacific fronts, typically lasting twelve to thirty-six hours, comprise the type of storm system which can generally be seeded. The large Arctic fronts which approach the area from the north and bring low temperatures, high winds and heavy snowfall are not considered seedable.

Monitoring System

A system for monitoring the effectiveness and effects of the proposed project has not been definitely established. However, Bonneville Power is planning to contract with an independent group to undertake this effort. The program will analyze soil, vegetation, snow and water runoff samples for

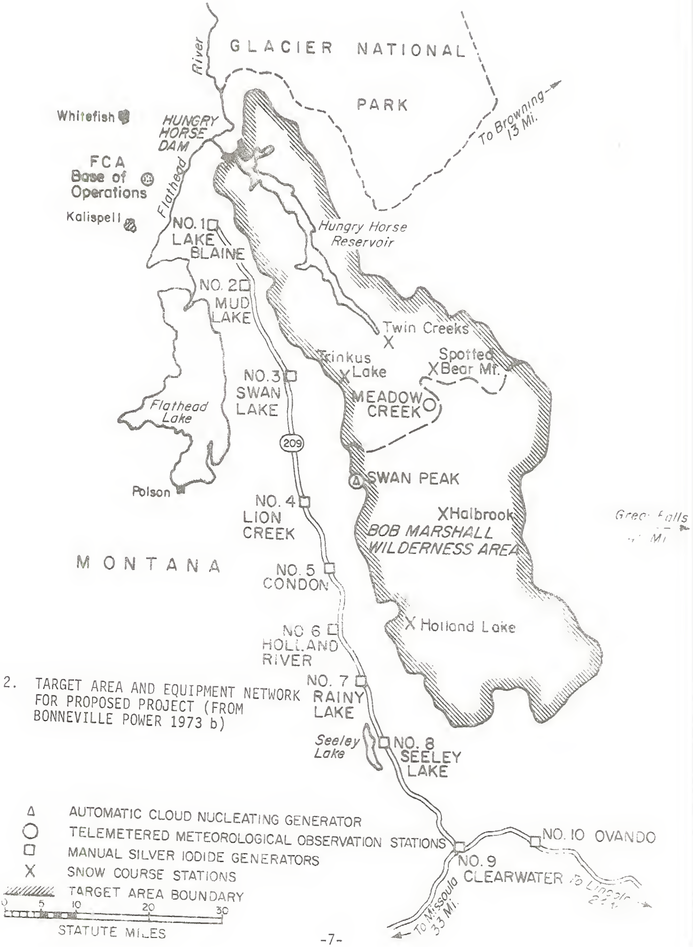

FIGURE 2. TARGET AREA AND EQUIPMENT NETWORK FOR PROPOSED PROJECT (FROM BONNEVILLE POWER 1973 b)

residual silver iodide; sampling will occur throughout the operational period. In addition to the target area, samples will be taken in areas adjacent to the target, especially to the northeast, to determine if downwind drift of the silver iodide is occurring.

III. EXISTING ENVIRONMENT

Vegetation

The target area straddles the continental divide and exhibits both westside and eastside conditions. Predominant tree species on the westside are western larch, Douglas-fir, ponderosa pine, lodgepole pine, spruce, subalpine fir, alpine larch and some whitebark and limber pine. Trees are slower growing east of the Divide and include Douglas-fir, lodgepole pine, spruce, subalpine fir, alpine larch, and some white bark and limber pine.

Much of the area was burned over between 1910 and 1934,resulting in large areas of dense lodgepole pine, Douglas-fir and shrubs. The presence of this shrub cover, along with increased production of forbs and grass, is of crucial importance to deer and elk.

The subalpine spruce type is most prevalent in the Bob Marshall Wilderness Area, followed by the mixed lodgepole pine/Douglas fir association, the Douglas-fir/lodgepole pine/ Engelmann spruce association, grass and Engelmann spruce type.

Although fire control and suppression activities influence natural plant succession, the vegetation occurring throughout most of the target area remains in a near-natural condition.

Climate

Regarding climate, the Bonneville Power Administration states:

> The various geographic features modify the climate in the Flathead Basin. These modifications significantly influence regional precipitation and air masses from the west, producing a milder climate than in the region east of the Continental Divide.
>
> Local temperatures are moderated by the influence of Flathead Lake, the numerous other bodies of water in the valley, and the high mountains which form an effective barrier to the severe winter cold waves that are often present east of the Rocky Mountains.
>
> There are considerable weather differences within the valley. For example, at Kalispell, the temperature extremes, snowfall, and wind velocity are less than at the Glacier International Airport Weather Station which is only 8 miles north of Kalispell. This is due in part to the ameliorating effect of Flathead Lake on weather in the southern portion of the county

Large volumes of snow accumulate in the higher elevations during the winter through April and then rapidly melt, often causing high flows in the spring. Precipitation falls every month of the year; however, much is stored and runs off in a 2- to 4-week period.

Generally, precipitation is greatest at the higher elevations of the North Fork drainage. Parts of the east side of this drainage receive 120 inches of precipitation annually, while the river bottom is in the 25-inch category. Precipitation ranges from 25 inches to 100 inches in both the South and Middle Fork drainages. Columbia Falls, which is about 5 miles south of the study area, receives 15 to 20 inches annually.

Precipitation is high in December and January and comes mostly in the form of snow, which is stored until spring runoff. June precipitation, which is also high, is primarily rain.

Temperatures in the study area typically range from a high of about 90° F. to below -10°F. The average annual temperature at Hungry Horse Dam is 44° F. and mean annual precipitation is about 26 inches (Bonneville Power Administration, 1973 b).

Hydrology

Streams are dynamic, yet in balance with their environment under ideal conditions. When man interrupts this system, streams may be forced to adjust to channel changes too rapidly. If successful, activities such as weather modification tend to increase stream-flow and surface runoff. A significant increase in volume of water places an excessive load on the stream channel and can cause flooding, severe erosion, pollution and other damage.

The Flathead River and tributaries carry heavy loads of silt during spring runoff. This erosion is mostly natural and is due primarily to undercutting of glacial outwash and glacio-lacustrine deposits along stream banks.

Throughout much of the study area there are large areas of natural erosion and evidence of the 1964 flood. The water quality of these streams is excellent during summer and fall.

Wildlife

The rich diversity of habitats resulting, in part, from protection of the wilderness resource of the area make this one of the most important wildlife areas in the nation.

The Bob Marshall Wilderness provides habitat for the grizzly bear and the northern Rocky Mountain wolf, both on the rare and endangered species list. There is very little information on the habitat needs of those species.

Elk populations have decreased over the past twenty-five years as indicated by harvest figures. Mountain goats also appear to be on the decline. Bighorn sheep are perhaps increasing in numbers. Large herbivores also include mule deer, whitetail deer and moose. Other wildlife species include mountain lion, bobcat, lynx, wolverines, fishers, otters, beavers and marmots.

Although no large concentrations of water fowl occur within the area, there are good upland bird populations which include blue, ruffed and spruce grouse, and whitetailed ptarmigan. Aproximately 200 other species of birds , mostly songbirds and birds of prey, inhabit the area. There are several species of hawks and owls, osprey, and both the golden and bald eagles.

Fisheries

Fish inhabit most of the area streams, rivers and lakes. Species include arctic grayling, rainbow trout, Dolly Varden, brook trout, Yellowstone and west-slope cutthroat trout, suckers and whitefish.

West-slope cutthroat trout is classified as a threatened species, according to the U. S. Bureau of Sport Fisheries and Wildlife. Both migratory and resident populations of cutthroat trout exist in the study area. Migratory cutthroat trout in the lower river may use Flathead Lake, whereas resident populations of the Middle Fork occur mostly in the upper portions of the drainage.

Social

The general life-style characteristic of those residing in the area is extensively inter-woven with the natural environment and opportunities for outdoor recreation. A review of public testimony presented at the October 19, 1971 weather modification hearing in Kalispell indicated that many residents harbor very strong feelings regarding the need to maintain the natural integrity of the area. This need extends far beyond the mere desire for recreational opportunities. In statements to the Montana Water Resources Board, many residents indicated they had very deep-seated emotional and moral feelings regarding the need to define and maintain the boundaries of man's disruption and modification of the physical and natural systems in the Flathead.

IV. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

An analysis of the environmental impact associated with the proposed operation is based on the assumption that the operation will accomplish its objective, i.e., increase snowpack by ten percent and thereby increase the possibility of an average or above average snowpack. Numerous unresolved questions surround the theory and application of weather modification efforts, and measuring the effects of a program is quite difficult. However, the probability of modifying and increasing precipitation from winter storms is greater than in the case of summer cumulus cloud modification programs. Available literature indicates that snowfall increases of ten percent are quite likely, and greater increases have been reported (Hannaford and Williams, 1968; Hastay and Gladwell, 1969; Lumb and Linsley, 1971; Super et. al., 1972). It is, therefore, on the basis of this literature that the projected effectiveness of the project is recognized and the following assessment of environmental impact is made.

Wildlife 1/

Large Mammals. The large mammals of most immediate concern are elk (Cervis canadensis), moose (Alces alces shirasi) and deer (Odocoileus sp.). With all of these species, it is accepted that available winter range constitutes the most likely limiting factor and establishes the carrying capacity of the area in question. The most relevant data in the affected area has been gathered on elk; consequently, this discussion is based on the impact the proposed action may have on elk.

However, the same principles apply to moose and the deer populations in the area. Rocky mountain goats (Oreamnos americana missoulae), on the other hand, utilize winter ranges usually associated with ridge tops and alpine areas. While these areas are likely to be kept free of snow by wind action, movement of goats from one winter range to another could be hampered by additional early snows. This could adversely affect movements of "billys" between "nanny/kid" groups during the late November breeding season.

As mentioned, the carrying capacity of the winter range is the key factor in survival of the elk population. (See figures 3 and 4). The condition of this winter range reflects many years of use and includes years of extremely heavy snowfall, years of light snowfall and years of average snowfall. Assumedly, during the below-average years, range plants have an opportunity to recover to some extent from heavy animal use during the more severe winter seasons. However, it takes many years for the range to recuperate from overuse. It is obvious that manipulation of snowfall to cause an average snowfall condition would preclude a low snowfall year wherein range plants have an opportunity to recover from heavy use during severe winter seasons. Also, the extent of winter range would be reduced. These conditions would have a detrimental effect on elk populations wintering in the proposed area of impact.

1/ The Montana Department of Fish and Game supplied the information for the preparation of those sections of this statement which deal with the impacts upon the wildlife and fisheries resources.

An assessment of the changes induced by weather modification must be based on local vegetative types and animal food habits. Extrapolation of data from areas far removed is highly speculative and of limited value.

Elk in the Flathead region have a diet consisting predominantly of browse plants. Rognrud and Janson (1971) report that browse comprises sixty to ninety percent of elk diets in the Flathead region with grass making up the remaining ten to forty percent. Forbs appear as a trace in the diet.

Of the browse species, the most important in the Middle and South Fork drainages of the Flathead River are chokecherry, serviceberry and mountain maple (Weckwerth, 1973). The most important grass, as determined by elk use in the Flathead region, is Idaho fescue (Rognrud and Janson, 1971).

The Montana Department of Fish and Game has maintained a number of transects within the impact zone to evaluate winter range condition. Data obtained with this sampling system reveals the precarious balance currently achieved between elk and their winter range. These transects employ the "point-quarter method" to determine characteristics such as plant density, height, and distance between plants.

In the South Fork of the Flathead River drainage, transects located on Phil, Woodfir and Lewis Creeks measure chokecherry, serviceberry and mountain maple. The Phil Creek transects reveal an average distance of 6.5 feet between key forage plants and an average height for these plants of 1.19 feet. The Woodfir transects reveal a 10.17 foot distance between key forage plants and an average height of 0.9 feet. The Lewis Creek transect shows a 6.19 foot distance between key forage plants and a 1.18 foot average height of plants on that transect.

In the Middle Fork drainage, transects located on Vinegar Creek and Lunch Creek measure serviceberry and mountain maple. In Vinegar Creek, the average height of these plants is 3.1 feet, and in Lunch Creek the average height is 2.1 feet (Weckwerth, 1973).

As pointed out previously, Idaho fescue is the most important grass in the diet of Flathead elk. In a recent study of the impact of weather modification in Montana, plants were classified as "late melt decreasers," those expected to diminish with increased snowpack, and "late melt increasers," those expected to increase with increased snowpack. Idaho fescue was identified as a late melt decreaser, or a plant that can be expected to decrease with increased snowpack (Haglund, 1972).

These winter ranges consist primarily of old burns which are presently being encroached upon by conifers in the normal fashion of plant succession. Continued fire suppression has prevented natural wild fires from enlarging the areas of suitable winter range; consequently, heavy use by elk, complicated by diminishing habitat, and now possibly to be further complicated by increased snowpack, are obviously going to have an impact on Flathead elk herds.

The elk herd in the South and Middle Forks of the Flathead River basin has had the lowest cow/calf ratio (a measure of herd productivity and survival) of all major elk herds in the State of Montana. This low productivity is a reflection of the nutritional level and overall environmental stress placed on the elk wintering under very severe conditions.

Data reveal that in the spring of 1972, after a severe winter, there was a survival of only seventeen calves per 100 cows as compared to a survival of twenty-six calves per 100 cows in 1973, following a mild winter. The all-time low for this area was fourteen claves per 100 cows (Weckwerth, 1973).

By way of contrast, elk in the Gravelly Range of southwestern Montana produce an average of sixty-one calves per 100 cows. Elk in the Little Belt and Bitterroot Mountains produce an average of fifty-four calves per 100 cows, and elk in the Sun River drainage produce an average of thirty-one calves per 100 cows (Rognrud and Janson, 1971).

Construction of Hungry Horse Reservoir eliminated some winter range, which led to a greater competition for food. Prior to 1954, there were a number of white-tailed deer wintering near the upper end of the reservoir. With restricted winter range due to the reservoir, the competition between deer and elk ended with the elk surviving and the white-tailed deer herd virtually eliminated. Weather modification in the basin may continue to compound these problems by restricting, through snow cover, remaining available range.

Movement of elk to winter ranges varies with snow conditions. Aerial flights in the last several years reveal that elk move toward this winter range shortly after the first of December (Weckwerth, 1973). It is conceivable that additional snow in November could start these migrations prematurely. Thus, the use of winter range would begin several weeks ahead of normal, putting additional stress on the winter ranges. This would not only have an adverse biological impact on the elk and vital vegetation, but could also force some limitations on the hunting season.

The most serious potential impact on the elk herd due to the proposed weather modification activities is the change in quality and quantity of vegetation available to them during the winter months. Aldo Leopold (1949) stated it very well when he said, "I suspect that just as a deer herd lives in mortal fear of wolves, so does a mountain live in mortal fear of its deer -- perhaps with better cause, for while a buck pulled down by wolves can be replaced in two or three years, a range pulled down by too many deer may fail in replacement in as many decades."

Small Mammals and Birds. Quantitative and qualitative data on small mammal and bird populations in the area are generally lacking. Although it has been previously cautioned that applying data acquired in one area to another has many limitations, small mammal studies in relation to weather modification in Colorado contained an interesting summary. This summary cited accumulating evidence that most small mammal populations increase with decreasing snowfall and presumably would decrease with augmented snowfall (Spencer, Steinoff and Sleeper, 1973). In any case, to begin modifying the habitat supporting these animals before basic inventories and habitat assessments are made will certainly entail some risk as to the nature of the ultimate impacts.

Fish

The primary game fish found in Flathead Lake and its tributaries are the westslope cutthroat trout (Salmo clarki), Dolly Varden (Salvelinus malma) and mountain whitefish (Prosopium williamsoni). In addition, the introduced kokanee (Oncorhynchus nerka) has successfully established itself in Flathead Lake and unobstructed tributaries to the lake.

Dolly Varden and cutthroat trout usually spend their adult lives in the lake environment and migrate upstream to spawn in tributaries, with the juveniles remaining for some time in the nursery areas of the tributary streams. Tagging studies reveal migrations of up to 100 miles in the Flathead River system. The lakes and their tributaries are thus closely tied, with one being entirely dependent upon the other (Hanzel, 1963).

The cutthroat and Dolly Varden from Flathead Lake migrate into the North and Middle Forks of the Flathead River and their tributaries. Both of these species are wild trout, existing in a system where they evolved. The large size of the entire system precludes any attempts to provide artificial populations from hatcheries; consequently, Flathead Lake and its tributaries are solely dependent upon wild populations of cutthroat and Dolly Varden trout.

Glacier National Park and the Flathead National Forest waters of the North and Middle Fork drainages thus rely upon this naturally-functioning system for their high quality fishery. The South Fork was once a part of this system; however, construction of Hungry Horse Reservoir has blocked all migrations from Flathead Lake into the South Fork drainage.

Prior to 1963, the average annual drawdown in Hungry Horse Reservoir was about sixty feet. Since that time, the average annual drawdown has been about 100 feet (See figure 5). Research over the past decade reveals that cutthroat trout in the reservoir averaged about sixteen inches in length prior to 1963. By 1973, this average had been reduced to only 13.8 inches in length. It has been estimated that a thirty to forty percent decline in fish populations has occurred during that ten-year period (Huston, 1967-1972). The correlation seems clear that current management of Hungry Horse Reservoir for the limited purposes of power production and flood control is continuing to deteriorate the quality of the aquatic habitat its very presence has so severely degraded.

In the event that weather modification allows still greater drawdowns, it is apparent that trout populations, not only in the reservoir but also in the entire tributary system, will continue to suffer adverse impacts. Greater drawdowns will also hamper fishermen from reaching impounded waters for angling purposes. It appears from available information that extreme drawdowns of

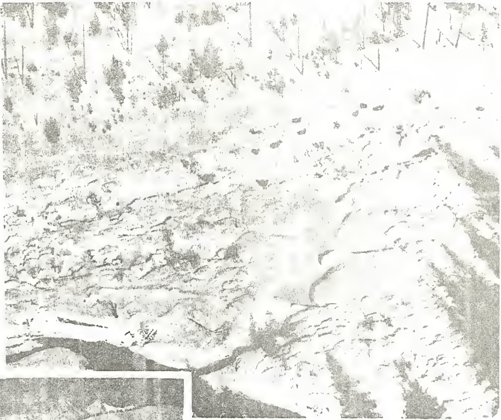

Figure 4
South Fork of the Flathead River winter range, Basin Creek

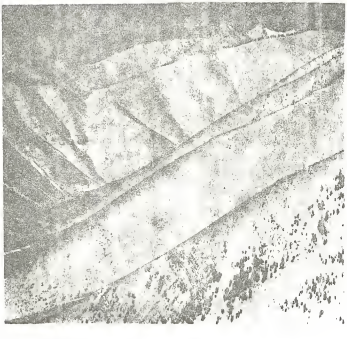

Figure 3
Above, Middle Fork of the Flathead River winter range, Lunch Creek

Figure 5
Right, Hungry Horse Reservoir showing extent of water withdrawals

Hungry Horse Reservoir are contemplated; the administrator of Bonneville Power has been quoted as advocating complete drainage of affected reservoirs (Hodel, 1973).

The primary spawning area for Dolly Varden trout which still live in Hungry Horse Reservoir is the Bob Marshall Wilderness -- the area of proposed weather modification. Tagged fish from the reservoir have been recovered in White River and Danaher Creek located in the Bob Marshall Wilderness area. Consequently, deteriorating aquatic conditions either in the reservoir or in the South Fork itself would be reflected by changes in fish populations utilizing aquatic habitat available in the wilderness.

A serious problem over the past decade has been barriers which prevent spawning fish from reaching available tributary space. In many cases these barriers were created by the cutting action of water flowing through culverts or the velocity of the water within the culverts. Some relief has been provided by installing gabions and by replacing culverts with bridges. Increased seasonal runoff would cause increased volumes, increased velocities and increased cutting action - possibly to the extent of negating corrective measures already taken by the U. S. Forest Service and the Montana Department of Fish and Game.

Over past centuries, the stream channels of this basin were carved and created to carry certain capacity flows. Increased flows can disrupt channels and destroy fish habitat. It has been stated that timber harvesting operations in many of the tributaries are designed to keep flows in a range not to exceed an increase of eight to ten percent. Weather modification, coupled with this already abnormal increase, certainly compounds the possibility of damaging stream channels physically.

Fisheries of cutthroat trout have shown a correlation between stream discharges and establishment of strong year classes. A strong year class represents a highly successful spawning and survival condition in a population of fish. Evidence of this is contained in papers written by Benson (1960), Bulkley and Benson (1962), Drummond and McKinney (1965) and Babcock (1968). In all cases, the researchers were working with cutthroat trout, and their data indicate that high flows during the spawning period will result in poor recruitment into lake or reservoir populations.

It is conceivable that Hungry Horse Reservoir itself will continue to decline as an aquatic habitat capable of sustaining fish. This will result from three basic problems: (1) the consistently extreme annual drawdown, (2) the increased rate of water exchange, and (3) the loss of essential nutrients due to the deep water penstocks which preclude a reservoir from functioning as a nutrient trap in the fashion that natural lakes do (Wright, 1967).

From the above discussed impacts, it appears that the variety of problems which presently exist in the South Fork drainage can only be compounded by attempts to modify weather and increase precipitation.

Vegetation

The direct and indirect impacts of the proposed action upon some grasses and shrubs have been discussed in the wildlife section of this statement. With respect to other vegetative components of the ecosystem, the research has been somewhat limited. Nevertheless, as snowfall is increased, certain impacts can be expected. Owen (1973) tentatively concluded that heavier snowpacks negatively affect the vegetative growth and flowering of the herbaceous layer. Fechner and Blaue (1973) observed that stem growth initiation in Engelmann spruce was largely independent of snow cover; however, rate-of-growth was significantly decreased by the presence of snow. Initiation of growth in aspen stands, in contrast with spruce, was negatively affected by the presence of snow cover.

With respect to alpine ecology, Webber et.al. (1973) found that a greatly increased snowpack on poorly-vegetated slopes will increase soil denudation and tend to decrease plant cover. It was found that on drier slopes, which are normally free of snow, a slight increase in snowpack will increase vegetative growth. It was concluded that snowfall increases of fifteen percent would very likely not have short-run effects on tundra vegetation. These findings are similar to those of Weaver and Super (1972), wherein it was found that snowpack increases would have to be twice the normal in order to induce significant vegetational changes.

A further effect of increased precipitation concerns nutrient cycling. It has been found that increased snowfall tends to lead to increased litter decomposition (Webber et. al., 1973). This increase was attributed to the greater time that the litter remained wet. The ultimate effect of such increases in decomposition would be increased nutrient release and cycling rates.

Determining whether the proposed one-year operation will adversely affect the vegetation is difficult, although research currently in progress will help in resolving this difficulty (Teller et. al., 1973). On the basis of the research cited above, the change in snowpack will likely have a direct effect on the vegetation; however, since the program is presently intended to last for only one year, the magnitude of any effect will probably be quite small. It should be noted that this conclusion does not consider any indirect effects the seeding will have on the vegetation, such as the impact of increased wildlife browsing due to winter range limitations.

Hydrology

The hydrologic impact of increased precipitation depends upon the amount of increased runoff generated. The amount of additional precipitation to be generated from the proposed cloud-seeding project is in turn heavily dependent upon the natural snowfall rate.

If the resulting snowpack were below to slightly above normal, the hydrologic effects would be minimal. Bonneville Power (1973 b) has stated that some additional scour and sedimentation would occur over that which would take place naturally. Nevertheless, since the total runoff would be well within the normal range, the hydrologic effects would be insignificant.

If the induced snowpack were somewhat above normal, the effects would become more significant. Channel scour and stream turbidity could increase considerably over that which would naturally occur. This would be particularly true in localized areas. Over the total basin, however, these effects would still be within the normal range.

Significant hydrologic effects could result if a heavy, late-season snowfall or rain occurred. This condition, coupled with an above-average snowpack, could cause significant localized flooding above Hungry Horse Dam. Channel erosion and sedimentation could be well above average in the basin as a whole. Significant upstream flooding could also destroy considerable fish habitat in the tributary streams.

An average snowpack combined with heavy late-season precipitation would cause the same effects, but that portion attributable to artificially-induced precipitation would be much less. Nevertheless, under the appropriate conditions, the additional amount of runoff from cloud seeding might make the difference between bank-full conditions and overbank flooding. The probability of large-scale flooding due to late-season storms on an average snowpack is remote, although a twenty percent chance exists that significant late-season precipitation will occur (Bonneville Power Administration, 1973 b).

Ground Water

During a recent land capability study by the Department of Natural Resources and Conservation it was found that many local residents in the Flathead Valley believe the pronounced rise in the water level of kame and kettle lakes in the valley has been partly caused by previous weather modification activities (Cunningham and Werth, 1973). These small "pothole lakes" with no surface inlet or outlet are simply a surface manifestation of ground water. Almost totally dependent on the ground water for recharge, these lakes have been rising since the late 1950's , resulting in the inundation of buildings and fences. While there is no scientific evidence attesting to the cause of the rise in water level, it is conceivable that weather modification could have been a contributing factor along with other natural and artificial activities.

Effects of Seeding Agents

As a means to affect certain physical processes within clouds, it is necessary to induce some type of seeding agent. Several different seeding agents have been used in various weather modification efforts; to a large extent, their specific physical and chemical properties dictate the situations under which they can be used. The seeding agent proposed for the project under consideration is silver iodide, the most widely used of the various agents. On a weight basis, silver iodide consists of forty-six percent silver and fifty-four percent iodine. The fact that silver is a toxic, heavy metal necessitates an analysis of its potential biological and ecological effects.

Available literature indicates that silver iodide, when used as a cloud seeding agent, will very likely not have a direct adverse impact upon the environment. Silver in the precipitation from seeded storms is rarely at a concentration that can be considered harmful. In analyzing the possible effects of silver contained in precipitation, Cooper and Jolly (1969) noted:

> Silver [Ag] in precipitation from non-seeded storms has been measured at levels up to 20 x 10^{-12} grams of silver per milliliter of precipitation (0.00002 ppm). Silver concentrations in precipitation from seeded storms range from 0.000001 to 0.176 ppm. Typical values are 0.0001 to 0.0003 ppm. This is of the same order as the concentration of Ag in normal seawater -- 0.00015 to 1.0003 ppm. Precipitation of this concentration would deliver 0.01 - 0.03 gm of silver per hectare per centimeter of rain.
>
> With rare exceptions, there is substantially less Ag in precipitation from seeded storms than is allowed by the U. S. Public Health Service standard for drinking water. Ag in excess of 0.05 ppm is considered grounds for rejection of a water supply. The highest concentration measured in snow from the Park Range in Colorado after cloud seeding experiments, 0.176 ppm, greatly exceeds the PHS standard, but most measured silver levels in snow and rain from seeded storms fall far below.

Similarly there is little possibility for the iodine in silver iodide to have an adverse environmental impact. It would be necessary to consume about 130 gallons of precipitation from a seeded storm in order to consume the amount of iodine in eggs sprinkled with iodized table salt. Biological effects have not been reported on the once common European practice of burning seaweed with accompanying release of iodine vapor. The concentration and toxicity of iodine in precipitation associated with current cloud seeding efforts have been sufficiently low that an ecological impact seems unlikely.

Dismissing the impact of silver iodide upon the environment is a realistic possibility when considering a short-term project. However, repeated projects or projects of much longer duration may lead to build-up of silver and perhaps unimagined metabolic or biologic impacts. Weaver and Klarich (1973) noted that:

> Because of the potential toxicity of silver, longer term use of this agent (1) should be preceeded [sic] by detailed studies of the transformations of silver that might occur in nature, of the effects of silver on higher organisms, and of the effects of silver in aquatic ecosystems, and (2) should be carefully monitored. Efforts to discover suitable alternative agents should be encouraged.

Downwind Effects

A recurring question about the consequences of a weather modification effort concerns the downwind effect. It is often felt that artificially-induced precipitation may have fallen in a location downwind of the target.

Weather modification is not analagous to withdrawing water from a stream or ground water source. It is more analagous to withdrawing water from the ocean, where any removal of water is quickly recharged. Seeding removes a small percentage of the available atmospheric moisture in a given storm system. As the system moves downwind, it is recharged by an inflow of moisture; this effect can be accentuated by cloud seeding.

Although research concerning downwind effects of weather modification is not conclusive, apparently some areas may receive greater amounts of precipitation while others receive less. The amount of any change in precipitation is an open question. It appears that often there is a trailing of the seeding effect as a weather system moves downwind.

Since the prevailing winds are southerly, the greatest downwind effect would be expected in the vicinity of Glacier Park, north of the target area. The most likely downwind effect of the proposed operation would be to increase precipitation in the vicinity of the park, resulting in environmental impacts similar to those in the target area. Any precipitation increases would probably be less than in the target area, and the magnitude of the impacts would be somewhat reduced.

Wilderness

Personal wilderness experience and vicarious appreciation. Weather modification is a component of the broader issue of whether the continued maintenance of a "higher standard of living" is worth its cost in things natural, wild and free.

For an increasing number of people, a major passion is the desire to periodically escape from technology and a mechanistic society. The enjoyment of solitude, independence, primitive travel and beauty affected by wilderness surroundings is essential to their happiness.

For a still larger segment of society, there exists the realization that, despite man's modification of ninety-eight percent of the United States, a small but priceless heritage of primitive America endures. This vicarious wilderness appreciation can be experienced even though the individuals may never or only rarely visit a wilderness area.

An important component of the physical aspect of wilderness, contributing to both vicarious and direct-user appreciation, is the weather. The realization that storm systems and weather fronts are essentially unmodified is vital to the wilderness concept. Conversely, unnatural precipitation detracts from both the personal and the vicarious wilderness experience.

Therefore, while nature may heal physical abuses over time, the harm done to human attitudes toward an increasingly scarce resource of natural systems is not so easily repaired. A sensitivity to these attitudinal values requires that such losses be recognized as a cost of the proposed action.

Wilderness Act. An issue of concern, raised in connection with the proposed cloud seeding program, is whether it will constitute a violation of the Wilderness Act of 1964 (Public Law 88-577). The declared policy of the Wilderness Act is to set aside certain "wilderness areas" to be protected and managed so as to preserve their natural conditions. It has been stated that the U. S. Department of Agriculture, Office of General Counsel and representatives of the U. S. Department of Interior Solictors have tentatively agreed that a cloud seeding program, producing only a transitory, insignificant impact on the ecology of a wilderness area, would not be contrary to the provisions of the Act (Corpe, 1973).

Others have a contrasting opinion. If the policy and spirit of the Act are to protect and manage certain undeveloped areas of federal land which are primeval in character and influence, and to preserve such areas in their natural conditions, then any attempt to alter a natural condition by artificial means, regardless of whether such alteration is transitory and insignificant, would be in violation of the Act.

It is evident that many unanswered questions remain as to whether a cloud seeding program is prohibited by the Wilderness Act. No authoritative statement of the law in this area has been made, and, until such time as there exists clear legal authority, it would appear that weather modification programs should be subjected to close scrutiny as possibly being violative of the Act.

The Northern Region of the United States Forest Service (Region I) has interpreted the Wilderness Act with regard to the permissibility of weather modification activities. The Region I policy is as follows:

> 2323.4 - Wilderness Water. Measures to increase precipitation are in violation of the wilderness criteria that "the earth and its communities of life be untrammeled by man." Cloud seeding and other precipitation producing measures cannot be permitted over a wilderness if the treatment will result in unnatural precipitation upon the wilderness. Snow fences, clearing of trees in certain areas, and other snow manipulation activities will not be permitted. (USDA, 1970)

Because the proposed weather modification activity, by its very nature, will result in "unnatural precipitation upon the wilderness," it appears that the proposed action may be in violation of Forest Service policy. Furthermore, the Water Resources Section of the U. S. Forest Service Bob Marshall Wilderness Plan (USDA, 1972) states that"... attempting to increase the snowpack in the South Fork of the Flathead River drainage by employing weather modification measures is in conflict with wilderness management objectives."

When a major piece of legislation such as the Wilderness Act lacks case law interpretation, it is helpful to consider the intent of Congress in its enactment of the bill. Although a precise determination cannot be made as to legally-permissible modification in a wilderness area, Congressional committee reports and hearings records concerning wilderness proposals in the early 1960's, leave an unmistakable impression that congressional supporters intended that areas designated as wilderness receive the strongest possible protection.

Scientific value of wilderness. The integrity of any biological system depends on its internal capacity for self-renewal and subsequent decline of land health are reflected by such indicators as disappearing plant and animal species in altered landscapes.

The scientific study of ecosystem integrity requires, above all, a base datum of normality, a picture of how healthy land maintains itself as a naturally-dynamic system. Attempting to restore the natural balance within an area requires the recognition that the individual is a memeber of a community of interdependent parts. Obtaining such to balance will be impossible without scientifically-tested comparisons between wild and unnaturally-disturbed areas. Each biotic system needs its own base datum of naturalness for comparative studies of artificially-modified and unmodified land. The physiology of the Flathead drainage cannot be studied in Colorado.

There is abundant paleontologic evidence that wilderness systems have maintained themselves for extremely long periods. Their component species were rarely destroyed and the natural processes of weather and water build soil as fast or faster than it is carried away. It is for reasons such as these that the wilderness state assumes major importance as a laboratory for the study of land-health.

Certain portions of the Wilderness Area can now serve (1) as a control for identifying the effects of man's activities, and (2) as a gene pool for the genotypes of both common and unique biotic associations. Further modification of the natural processes occurring within, and adjacent to, the Bob Marshall Wilderness Area will foreclose these options.

Glacier Park

Glacier National Park was established to protect and preserve a unique and representative area of the northern Rocky Mountains. Enabling legislation and subsequent policy guidelines recognized the park as a natural area within which the integrity of indigenous biotic communities would be maintained. Management planning to assure retention of natural systems and their component parts considers the complex of internal park environments as well as those factors which may induce undesirable change. Change-inducing factors are not limited to park sources but can, and do, include effects from activities on lands surrounding the park. Such activities include proposed weather modification.

Martinka (1973) stated that:

> Alterations of natural hydrologic cycles through artifically induced precipitation carry the potential for ecosystem response within the boundaries of Glacier National Park. Current studies of winter ungulate [deer, elk, moose] ecology downwind from the target area suggest that one manifestation might include reduced population stability through restricted variability of winter weather. Again, departures from natural conditions may be expected from an extrinsic influence.

Within the framework of Congressional mandates, policy guidelines for natural areas, and scientific inquiry, it must be recognized that such activities may conflict with attempts to maintain Glacier National Park in a natural condition.

Recreation

Unless very heavy snowfall and runoff result, any impact of cloud seeding upon recreational use will probably be confined to Hungry Horse

Reservoir. While no direct recreational benefits were assigned to the construction of Hungry Horse Dam itself, recreational development has taken place in association with the reservoir. The U. S. Forest Service has leased land for twenty-one home sites at Weinrude Point, and, in addition, there are 150 family camping units, sixty-six picnic units, six developed beaches and eleven boat ramps. Developed recreational facilities, such as the three dude ranches in the Spotted Bear vicinity, are also within the proposed seeding area. Other popular recreational activities within the area include hunting, fishing and backpacking.

Possible impacts upon this recreational use in the target area may result from extensive drawing down of the reservoir in anticipation of having cloud seeding create a sufficiently-heavy snowpack for refill (Hodel, 1973). The potential impact would be heightened if an insufficient snowpack developed. For example, the drawdown would create problems of access for shore fishermen, boaters and swimmers. In addition, other factors associated with drawdown, such as excessive mudflat areas, will tend to decrease recreational use by both the resident and non-resident recreator.

Economic

A determination of economic impact associated with the proposed project is based upon the extent to which the program is successful. It should be recognized that all the power benefits of cloud seeding will not be available only during the February-April deficit period. Nevertheless, the following comparison does provide some perspective as to the relative magnitude of the problem and the extent to which cloud seeding may alleviate the situation.

On the basis of estimates provided by Bonneville Power for a critical water year (1936-37 conditions), and if the winter cloud-seeding is successful, the run-off into Hungry Horse Reservoir will be increased by approximately 76,500 acre feet. This will constitute a total net increase in power generation within the entire system (Federal and non-Federal) of 158,976,000 KWH. Comparing this with the 4.6 billion KWH deficit projected under critical water year conditions, it can be seen that weather modification will alleviate the deficit by 3.5 percent.

Using median water conditions, Bonneville Power projects a run-off increase at Hungry Horse of 106,685 acre feet with a power generation increase of 221,568,000 KWH. Median conditions would, of course, reduce the projected 4.6 billion KWH deficit to some extent. For comparison purposes, this increase would alleviate 4.8 percent of the 4.6 billion KWH deficit projected for the Pacific Northwest. It should be kept in mind, however that a high probability exists that a median water condition will occur and the projected power deficit will be reduced through normal snow conditions, regardless of whether the proposed weather modification program is implemented.

Although the proposal and most of the Columbia System are Federal and inter-state in nature, it is meaningful to estimate the possible impact on Montana. The power shortage projected by Bonneville Power is expected to have little if any effect on Montana east of the Divide.

A share of the projected shortage and the possible new power (from cloud seeding) can be allocated to western Montana. With respect to power consumption (Federal and non-Federal), Montana consumes 8.83 percent of that consumed by the entire four Northwest States. Bonneville Power provides 37.9 percent of the power consumed in Montana. Therefore, an estimate of western Montana's share of the load and the shortage is 37.9 percent of 8.83, or 3.35 percent. Because of non-Federal power from the Columbia System going to Montana, the figure of 3.35 percent is probably low, and, therefore, it is assumed that the share is 5 percent. On the basis of these figures, the following summary table has been prepared:

Power Summary -- Projected Shortages and New Power
From Cloud Seeding for Montana and the
Northwest1/

		Median Water Conditions	Critical Water Conditions
NORTHWEST 2/	Power Shortage (Feb-April)	Unknown	4.6 billion KWH
	New Power from seeding	221,568,000 KWH	158,976,000 KWH
MONTANA	Power Shortage (Feb-April)	Unknown	230,000,000 KWH
	New Power from seeding	11,078,400 KWH	7,948,800 KWH

1/ Northwest data provided by Bonneville Power; consult text for methodology and assumptions in allocating Montana's share.

2/ Pacific Northwest coordinated power system.

On the basis of assumptions stated earlier, Montana's share of power from cloud-seeding in the Hungry Horse System will probably be between 7.948 million KWH and 11.078 million KW. The amount depends upon whether critical or median conditions develop. The table below shows what this quantity of energy can do in different uses. These figures are for illustrative purposes only and do not imply that the electrical users noted below will bear the burden of the shortage:

Montana's Share of the New Power
From Cloud Seeding

	Median Water Conditions	Critical Water Conditions
Energy	11,078,400 KWH	7,948,800 KWH
Will supply X Homes for one year[1]	738 homes	530 homes
or		
Will run the Stauffer chemical plant for X days[2]	9.5 days	6.8 days
or		
Will run the Anaconda Aluminum Plant at full capacity for X hours.	30 hours	21.5 hours

[1] Assumes 15,000 KWH/home year
[2] Assumes 1.16 million KWH/day
[3] Assumes 370,000 KWH/hour

V. ALTERNATIVES

Maintain the Status Quo

The most obvious alternative is to not undertake the weather modification effort. The Pacific Northwest is facing a potential power deficit, and Bonneville Power has estimated that by spring the deficit will be approximately 4.6 billion kilowatt-hours. The proposed cloud seeding program will increase generating ability by about .22 billion kilowatt-hours. In other words, the proposed effort will alleviate the deficit by about five percent.

Accepting the null alternative will not directly help to alleviate the power shortage; however, the percent of power increase which can be attributed to weather modification is small. Determining whether the small increase is worthwhile involves assessing the tradeoffs between benefits accruing from weather modification and those from maintaining the status quo. If the null alternative is accepted, greater reliance will probably be placed on using other alternatives to the proposed action.

Establish a Different Target Area

Currently, extensive cloud seeding is being considered for portions of Washington, Idaho and British Columbia. Therefore, a reasonable possibility exists that the weather modification could be conducted elsewhere in the Columbia River Basin. Such an action would likely involve seeding an area that would affect fewer hydroelectric dams and thereby reduce the benefits which can be attributed to such an effort. Bonneville Power (1973) has chosen the Hungry Horse area for a weather modification effort because of prior seeding experience in the area and the likelihood of greater effectiveness. However, such an alternative would avoid such problems as unnatural weather conditions within a wilderness environment and adjacent lands within the target area. Changing the environment of an alternative target area may be more acceptable than briefly altering the natural state of the wilderness. This of course would depend upon the location of the alternative area.

Reduce Power Demand

Reduce power demand during the critical period. Reduction of power demand, through the implementation of voluntary and/or mandatory energy conservation controls on the private and commercial sector, constitutes a possible alternative to the proposed action. Rather than meet power demand during the critical period, the demand could be reduced by an amount equivalent to the additional power derived from runoff expected with weather modification.

Currently, various degrees of both voluntary and mandatory power cutbacks are in effect in the Pacific Northwest. In Montana, Governor Judge has ordered a ten percent reduction in electrical usage by state government. He has asked for voluntary cooperation from all sectors of the state to reduce energy requirements by ten percent and will seek comprehensive power from the 1974 Legislature to enable him to take emergency action should the situation worsen. Along with this action, the Montana Public Service Commission has ordered the reduction of illuminated outdoor advertizing. The state of Oregon has initiated mandatory measures in an attempt to reduce that state's demands by 7½ to 10 percent; other states also have voluntary programs operative. By comparison, reducing normal consumption in the Northwest by two-tenths of one percent would save the equivalent of the additional power generation resulting from the proposed cloud-seeding operation.

Control demand by price mechanism or rate structures. Another alternative to the proposed operation is to allow the price of electrical power to increase as the energy resource becomes scarce. Such an action may provide strong incentives for conserving and more efficiently using power.

In the past, the Pacific Northwest has had relatively cheap and abundant power. As a result, electric use per domestic customer is double that of the national average with the effect of subsequently reducing the use of other sources (Pacific Northwest River Basin Commission, 1970, Table 5). Bonneville Power has undertaken an in-depth study of its rate structure in preparation for submitting a wholesale rate increase proposal to the Federal Power Commission. The estimated rate increase will be approximately twenty-five percent and will become effective December 20, 1974. According to Bonneville Power the effect of this wholesale power rate on electrical consumption is, "not clear." However, recent studies suggest that raising prices in order to reduce the demand may be an effective means of promoting energy conservation (Chapman et.al.,1972; Mooz and Mow, 1972). Bonneville Power's proposed rate increase is a long-term alternative to the proposed action. If, however, the proposed rate increase were soon to become effective, it could be considered a reasonable alternative to the proposed action.

A related and direct means of reducing power demand may be to base rate structures on the amount of power used. Present rate structures provide for reduced unit prices as the volume of use increases. Reversals in basic rate structure, if promptly implemented, may be an alternative. However, Bonneville Power, in its draft environmental impact statement for the proposed cloud seeding program, states ..."power pricing techniques... would not be available during the time period affected by the current cloud seeding proposal."

Another pricing mechanism may involve placing a surcharge on electrical usage during peak months or critical periods; additional revenue could support energy conservation programs or research.

Reduce power demand by increasing the recycling of aluminum. The Pacific Northwest region has attracted the energy-intensive aluminum refining industry because of the historical abundance of power. Currently this industry accounts for one-third of the total power use in the Pacific Northwest.

Perry (1972) indicates that the large amounts of energy used in producing aluminum could be avoided if more of this metal were recycled but that recycling is not without problems. The growth in number of new alloys, coupled with the cost of collecting the material, identifying the various alloys and mixing various types to obtain a satisfactory product has made recycling increasingly complex. On the other hand, if it were decided to increase the recycling of aluminum products, it would be possible to arrange a system to facilitate identification and collection of discarded aluminum products. The energy savings of secondary recovery could be substantial in that it requires about one-twelth the energy required by producing aluminum from ore. (Perry, 1972).

Recycling of aluminum is a long-term alternative that would not be feasible with regard to the current power situation. However, it is an alternative that must be considered when confronted with the long-range energy situation.

Increase Power Supplies and/or Production

Increase thermal generation in the Northwest. Bonneville Power, (1973 a) commented on this alternative as follows:

> All of the Pacific Northwest thermal generating resources that can be operated within current pollution laws and regulations, including some generation plants that would require variances from specific regulatory, requirements have been included in power forecasts. There is no unused thermal generation that is available.

Bonneville Power and investor-owned utilities have discussed plans to install about 600 megawatts of additional combustion turbines which, when installed, could assist in alleviating power deficits in future years (Bonneville Power Administration, 1973 a). Combustion turbines, while an effective measure to eliminate electrical power shortages, require large amounts of fuel, oil, or natural gas which are expensive and in short supply.

Increase hydro generated capacity in the Columbia River System. Several existing projects within the Federal Columbia River System are not operating at the total authorized generation capacity and other projects are either being constructed or have been authorized. Power generation specifications for the Federal Columbia River Power System are as follows (Bonneville Power Administration, 1973):

Existing Capacity (KW)	Capacity Under Construction (KW)	Additional Authorized Capacity (KW)	Additional Potential Capacity (KW)	Total Capacity (KW)
9,952,900	7,195,880	4,168,500	5,741,000	27,058,780

Although additional generation capacity in the Federal Columbia River System is possible in the future, this hydro generation potential will not provide an immediate alternative to the proposed action and is therefore only a long-term alternative.

Authorization of short-time overload of hydroplants. Short-time overload of hydroplants was authorized in 1971 by the Bonneville Power Administration when low stream flows in the Columbia River Basin threatened a Pacific Northwest power shortage (Richmond, 1971). This measure, if used, would increase the generating capability of existing hydro generation plants. This is a short-term measure that could somewhat alleviate the problem although it may have an adverse impact upon the generators.

Reducing the export of firm power from the Northwest.[2] The Pacific-Northwest area both imports and exports power. These power exchanges are made for a variety of reasons, the primary reason being a surplus of electrical energy in one region and a deficiency in another. (Pacific Northwest River Basin Commission, 1970). The total amount of energy imported and exported to the region during calendar year 1971 is shown below: (Pacific Northwest River Basin, 1972).

	IMPORTED (MWH)		EXPORTED (MWH)	
	Firm	Non-Firm	Firm	Non-Firm
BPA	0	119,878	0	2,158,829
OTHERS	294	11,280	4,906,868	2,374,221
TOTAL	294	131,158	4,906,868	4,533,050

Although the Bonneville Power does not export firm power, the utilities in the region export substantial amounts. Regarding the general exportation of firm power, the Pacific Northwest River Basins Commission suggested, (1970):

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[2] Firm power is that which a supplier is firmly committed to provide. In the Columbia River system the amount of firm power is based upon the capacity to produce under critical conditions.

> In most instances, however, the resource [firm electric power] exists as a surplus only over a limited period of years and therefore provides no firm resource to the importing area on a long-term basis.

Perhaps the time has arrived when the Pacific Northwest region no longer has a surplus of firm power equal to the export, thereby creating a power-short situation. If this were the case, a reduction of exports of firm power would help alleviate present and future power shortages.

The commitments to export firm power from the region are covered by contractual agreements. Therefore the alternative to reduce firm power exports is not an immediate alternative to the proposed action, and must be considered a possible long-term alternative.

Importation of power. One direct way to increase power supplies is to import greater amounts of power. Bonneville Power (1973 b) discusses this alternative:

> Because the daily and yearly patterns of demand for electricity vary between regions, and for reliability purposes, interregional interties have been constructed to tie the Pacific Northwest transmission system to southern California and Canada. Excess energy in one region that is needed in another can be transmitted over these interties.
>
> Substantial use is made of this capacity. Since October 1, 1972, about 4 billion kilowatt-hours have been imported into the Northwest from Canada and California. If a similar shortage exists in the 1974-1975 operating year, similar measures would be taken.
>
> However, this alternative source is limited by the fact that only energy which is surplus to the needs of the other regions can be obtained. During the current shortage, much of the imported energy is from Canadian hydroelectric plants. Since the availability of hydroelectric generation depends on weather conditions that cannot be forecast a year in advance, we cannot be confident that excess energy, even to the current level, will be available for importation from Canada next year.
>
> We are also currently obtaining some small amounts of surplus thermal generation from southern California. This generation is limited by a number of factors, including

shortages of fuel -- especially low sulfur petroleum-- and limitations on operation of thermal plants because of environmental constraints.

The level of energy that is being imported has not been sufficient to alleviate the current shortage. It is anticipated that if a significant shortage continues in the 1973-74 and 1974-75 operating season, even the present levels of imported energy, which may not continue to be available, would not be sufficient to alleviate the shortage. Therefore, importation of power does not represent an alternative to cloud seeding.

In summary, there is insufficient generation from local sources or from other regions to meet possible power shortages in 1973-74 and 1974-75, even when used in conjunction with energy conservation practices. While high-cost local thermal generation and power importation from other regions could and would be drawn upon to the extent available during a shortage, they must be considered an adjunct, rather than an alternative, to cloud seeding.

VI. RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

As noted earlier in this statement, a potential short-run benefit to accrue from the proposed weather modification program is a limited reduction in an anticipated power deficit for the Pacific Northwest during the coming winter. This short-run benefit must be balanced against potential long-run impacts, most notably, the impacts to wildlife, fisheries and wilderness discussed in Section IV of this statement.

The wildlife populations of the area in question presently exist under severe environmental conditions. As reflected primarily in the low cow/calf ratios for elk. Vegetation supporting the wildlife is a major influence. If snowfall were manipulated to cause an average snowfall condition,it would preclude a low snowfall year wherein range plants have an opportunity to recover from heavy use during severe winters. Also, the extent of winter range would be reduced. Such alterations would necessarily have a detrimental effect on elk populations wintering in the proposed area of impact. Furthermore, the low average height of key browse species and the response of Idaho fescue to increased snowpack certainly indicate the vulnerability of elk to increased snow depths. The problem is compounded by natural plant succession which is encroaching on limited winter range areas. This situation, coupled with weather modification in the Hungry Horse watershed, can only lead to overall deterioration of wildlife ranges with a subsequent long-term impact upon the productivity of the wildlife resource.

Previous drawdowns have negatively affected the fisheries resource of Hungry Horse Reservoir and the South Fork of the Flathead River. Drawing the reservoir below planned levels, in anticipation of having weather modification create sufficient precipitation for refill, will very likely further impact this resource which has not recovered from previous heavy drawdowns. In the event that an insufficient snowpack develops, the impact to the fisheries resource would be greater. Both situations negatively influence the long-term productivity of the fish populations; the duration of this effect will depend upon the magnitude of the drawdown and ensuing runoff.

With respect to wilderness, the proposed effort may have an effect upon long-term productivity. To the extent that cloudseeding modifies the natural weather regime within the wilderness and introduces unnatural amounts of silver, it can reduce its productivity for natural area research efforts. Whether cloud seeding will decrease the productivity of this resource for non-consumptive or intrinsic values will depend upon the users' perception of wilderness. Of course, the relationship of short-term benefits from this proposal to long-term productivity of wilderness values may become moot depending upon a legal determination of whether the proposed action violates the Wilderness Act.

VII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

With respect to the wilderness, wildlife and fisheries resources, the implications of this proposed activity are potentially adverse. As a nation we are running out of undeveloped land that can produce and sustain healthy fish and wildlife populations characteristic of wilderness and wild areas. Any activity contributing to the degradation of such an environment must at this time be considered an irretrievable and possibly irreversible commitment.

The values associated with a wilderness experience, though intangible, are nonetheless real because they evoke human emotion and sensitivities. The manner in which an individual perceives wilderness is a personal reflection. To some wilderness is viewed as a "locking up" and wasteful use of utilitarian commodities. To those persons, cloud seeding in the wilderness would not be an irretrievable commitment of a resource. To others, wilderness is viewed as an irretrievable, fragile and increasingly valuable resource. To these people, a snowfed stream, a dramatic winter storm, or a glacier lily cropping up along a receding snowdrift all help produce attitudes which are based on the perception that man is but a part of nature. Activities which diminish the naturalness of wilderness also diminish the vicarious values and attitudinal qualities that are an integral part of wilderness perception. Although weather modification has previously occurred in the Bob Marshall Wilderness Area, the continuation of such activities will cause a further degradation in the perception of wilderness quality that may not be replaced.

The significance of the natural area aspect of wilderness has been discussed earlier in this statement. It was concluded that the unnatural modification of the Bob Marshall Wilderness diminishes the quality of a natural area as base of normality. The extent to which weather modification alters the natural state is an irreversible commitment of a unique resource.

The use of silver as a component of the silver iodide seeding agent essentially constitutes an irretrievable commitment. Depending upon the nature of the winter storm systems, the project would use between six to nine pounds of silver. Consuming this small amount of silver, although irretrievably committed, will have only a slight effect on the total reserves.

Fossil fuels expended in conducting the project represent an unavoidable , irretrievable commitment of resources.

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